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ABSTRACT

This study compared the efficiency (time) and accuracy of two representations of instructional algorithms--list versus flow chart--for the task of using indexes to search for document numbers in the U.S. Documents Monthly Catalog. Participants were 55 undergraduates and 5 adults at the Virginia Military Institute. Two sets (flow charts and lists) of six algorithms were developed and field tested. The algorithms consisted of an average of three decision steps and five action steps; the steps for the list representations used the same directions presented in a numbered list sequence, with decision options referencing different step numbers. Subjects were randomly assigned to treatment group (list and flow chart) and given an instruction sheet and practice exercises on how to use their respective type of algorithm. Each participant was individually timed while working through the algorithms. Both groups completed the questions with 91.7% accuracy; however, the flow chart group (N=9) had a significantly higher number of requests for assistance than did the list representation group. It is suggested that this could be attributable to the novelty of the instructional form. The list group (M=5.24) completed the problems only slightly faster than the flow chart group (M=5.28). It is concluded that, while subjects indicated positive attitudes toward the use of algorithms, the specific form of representation appears to have little effect on the efficiency or accuracy of the search. A list of references, two data tables, and sample instruction sheets are provided. (JB)

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List vs. Flow Chart Representations of Algorithms for a Search Task

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ABSTRACT

This study compared the efficiency (time) and accuracy of list versus flow chart representations of the task of using indexes to search for document numbers in the U.S. Documents Monthly Catalog. Participants independently used the algorithms and were timed in a real world setting. Both groups performed at a 92% accuracy level. Both groups required virtually identical times to locate document numbers using each of the four indexes of the catalog, though the range of time and resultant variances were high. It appears that the form of representing algorithms has no effect on the algorithmic process during a search task.

INTRODUCTION

Algorithms are often used in education to depict general procedures which describe a class of problems. Algorithmic procedures normally are distinguished from linear procedures, which are represented as sequential lists of discrete operations. Algorithms, on the other hand, represent decision rule procedures in which a set of rules is systematically employed to make decisions and take appropriate actions. Algorithms are designed so that they always produce the correct result, given any of a class of decision rule problems. They may serve as instructional media or as job performance aids, which indirectly instruct users. Numerous studies have verified the effectiveness and efficiency of algorithms as instructional media (Landa, 1974; Scandura et al, 1971; Schmid et al, 1976).

While many people associate instructional algorithms with flow charts, Merrill (1980) illustrated four different representations for algorithms -- decision tree, decision table, flow chart and list representations. In this study we compared the efficiency and accuracy of two of the more popular representations, flow chart and list representations, for facilitating a search task. Very little research was availble to assist us in generating hypotheses. Coscarelli (1978) reported that the form of representation (list vs. flow chart vs. prose) did not affect critical thinking ability or course grades, however, using flow chart algorithms, students reduced their completion times. Coscarelli (1978) believed that different representations for algorithms possessed different media codes, which should affect the recoding of information into mental operations. Recoding differences should result in performance differences. In a study employing limited information processing tasks, flow charts were found to produce faster decision making than lists, with an equivalent level of accuracy (Holland & Rose, 1981). Evidence seems to indicate that flowchart representations of algorithms enables users to learn more efficiently. The questions that we addressed was, would these results generalize to a meaningful search task

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performed witout assistance in a real-world setting?

METHOD

Participants

55 undergraduates and 5 adults at the Virginia Military Institute (26 male, 4 female).

Materials

Two sets (flow chart and list) of six algorithms were developed and field tested. Each set of algorithms depicted the decision-rule procedure for using each of the indexes (subject, author, title, and keyword) and locating document numbers in the Monthly Catalog, the primary accession tool to U.S. Government Documents in depository libraries. The first algorithm in each set presented decisions which led to the appropriate algorithm and index. Each of the next four algorithms in each set directed the users through each of the indexes (see Figures 1 and 2 for examples of both types of algorithms for one index). The final algorithm showed how to find the document number in the catalog. The algorithms consisted of an average of 3 decision steps and 5 action steps. The flow chart versions used four common flow charting figures (rectangle, diamond, oval, and circle) to represent action, decision, terminal, and connector steps respectively. The steps for the list representations used the same directions presented in a numbered list sequence, with decision options referencing different step numbers. Both sets of algorithms were presented on six 8 1/2" X 11" pages.

Procedure

Content validity was established by submitting the materials for review by the head documents librarian and a library science professor. Then, each set of algorithms was pilot tested with naive users. No changes were found necessary. The participants in the study were unfamiliar with either the Monthly Catalog or the use of algorithms. They were randomly assigned to treatment group (list and flow chart). Each was first given an instruction sheet and practice exercise on how to use their respective type of algorithm. Next, all participants were presented individually with the set of algorithms and a set of four problems, each requiring the use of a different index in order to locate a citation and then the document number. That is, the search required each user to use one algorithm to determine the needed index, a second index-specific algorithm to find the citation, and a third to locate the SUDOC number. Only the Monthly Catalogs for the years 1980-1983 were used for searching, in order to limit the scope of the task. The order of the problems was randomized. Each participant was individually timed as s/he worked through the algorithms in order to locate the document number taking as

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long as they needed to locate it. They were told not to request assistance unless absolutely necessary. Following treatment, each participant completed the Extended Range Vocabulary Test from the Kit of Factor Referenced Cognitive Tests as a global measure of verbal ability.

RESULTS

Verbal ability

There was no difference between groups on the first part of the Extended Range Vocabulary test (M(list)=12.47 and M(flow chart)=12.93). We concluded that both groups were equivalent in their reading ability.

Accuracy

Both groups completed the questions with 91.7% accuracy. The flow chart group (n=9) had a significantly greater number of requests for assistance than did the list representation group (n=2), $\chi^2(1)=5.67$, $p<.02$. These requests related to the procedure for locating the indexes or which index to locate.

Time

Only minute differences in the times required by participants to locate documents resulted (see Table 1). The list group (M=5.24) completed their problems only slightly faster than the flow chart group (M=5.28). The range of times was very high, producing a large amount of variance in the data. The analysis of variance indicated a significant main effect. Post hoc analysis indicated the the title problem required significantly less time (M=4.39) than the other questions (M=5.42). The question by treatment interaction was not significant indicating no differntial effects of treatment.

CONCLUSIONS

The use of algorithms to introduce search procedures is effective insofar as most of the naive users were able to locate the information they sought independently. Also, the experience was positively received by all participants. Most of them reported positive attitudes toward the use of algorithms. Since the effectiveness of algorithms relative to list procedures has already been established, this study was concerned with alternative methods for representing the same algorithmic process. However, the form of representation appears to have little effect on the efficiency of the search. The accuracy of the search does not seem to be affected either, at least in terms of the proportion of citations located. Holland and Rose (1981) recommended practice with algorithms prior to performance because they (both list and flow chart) are generally unfamiliar forms of instruction. They found that the flow chart, after practice, elicits the best performance. The greater number of requests for assistance in this study by

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the flow chart users was probably attributable to the novelty of that form of instruction. So, with practice, the efficiency of the flow chart group in this study might have improved. Practice with any procedure is important. However, it was deemed likely that in an engineering-oriented, predominantly male school (such as the one in which the study was conducted) that some of the participants were familiar with flow charting. The intent of this study was to investigate the use the algorithms for providing independent access to materials in order to supplant the need for personnel to assist in the process. While either form may be used with equivalent efficiency and resultant accuracy, the additional requests for assistance, if found to be a consistent trend among naive users, would suggest the preferred use of list algorithms.

However, the efficiency and resultant accuracy of the two different forms of algorithms in this study suggest that it is the technology of algorithmization that makes the processing difference - not the form of its representation. The media codes are structural and therefore implicit in the algorithmic process and not specific to its form of representation.

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Table 1
Mean Location Times for Indexes
by Type of Algorithm Used

	Author	Title	Subject	Keyword
List	6.05	4.11	4.97	5.48
Flowchart	5.49	4.85	6.04	5.51

Table 2
Results of Two-Way ANOVA

	Sum of Squares	Degrees of Freedom	Mean Squares	F
Type Search	29.01	3	9.67	1.16
Treatment	3.05	1	3.05	0.365
Type X Treat.	12.05	3	4.02	0.481
Error	935.69	112		
Total	979.81	119		

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Figure 2

List Representation of Algorithm

1) Start here with the AUTHOR of a government document.

2) Find the CUMULATIVE AUTHOR INDEX to the Monthly Catalog. The indexes, along with the Monthly Catalog, are located on Index Table .

3) Select the AUTHOR INDEX volume for the year your document was published. If you do not know the year, use your best guess.

4) Is your AUTHOR one or more persons? If yes, go to Step 5. If no, go to Step 6.

5) Select one of your AUTHORS and look up the last name, followed by the first name or initials. Go to Step 7.

6) Your AUTHOR must be a corporate or government agency. Look up the first major word in the corporate agency. Do not use a, an, the.

7) Did you find your AUTHOR? If no, you may have the wrong year. Go back to Step 3 and select the year earlier or the year later. If yes, go to Step 8.

8) There may be more than one title attributed to your AUTHOR. Select the one you want. Find the ENTRY NUMBER following the title.

9) The ENTRY NUMBER looks like this: 83-16997. The first two digits (83) indicate the year and volume number of the Monthly Catalog.

Write down your ENTRY NUMBER.

10) Find the volume of the Monthly Catalog for the year indicated by your ENTRY NUMBER. ENTRIES are listed in numerical order. The numbers contained in a volume are indicated on the spine.

11) Did you find your ENTRY? If no, you may have the wrong volume. Look at the inclusive numbers listed on the spine to see if yours fit. Go back to Step 10. If yes, go to Page 6.

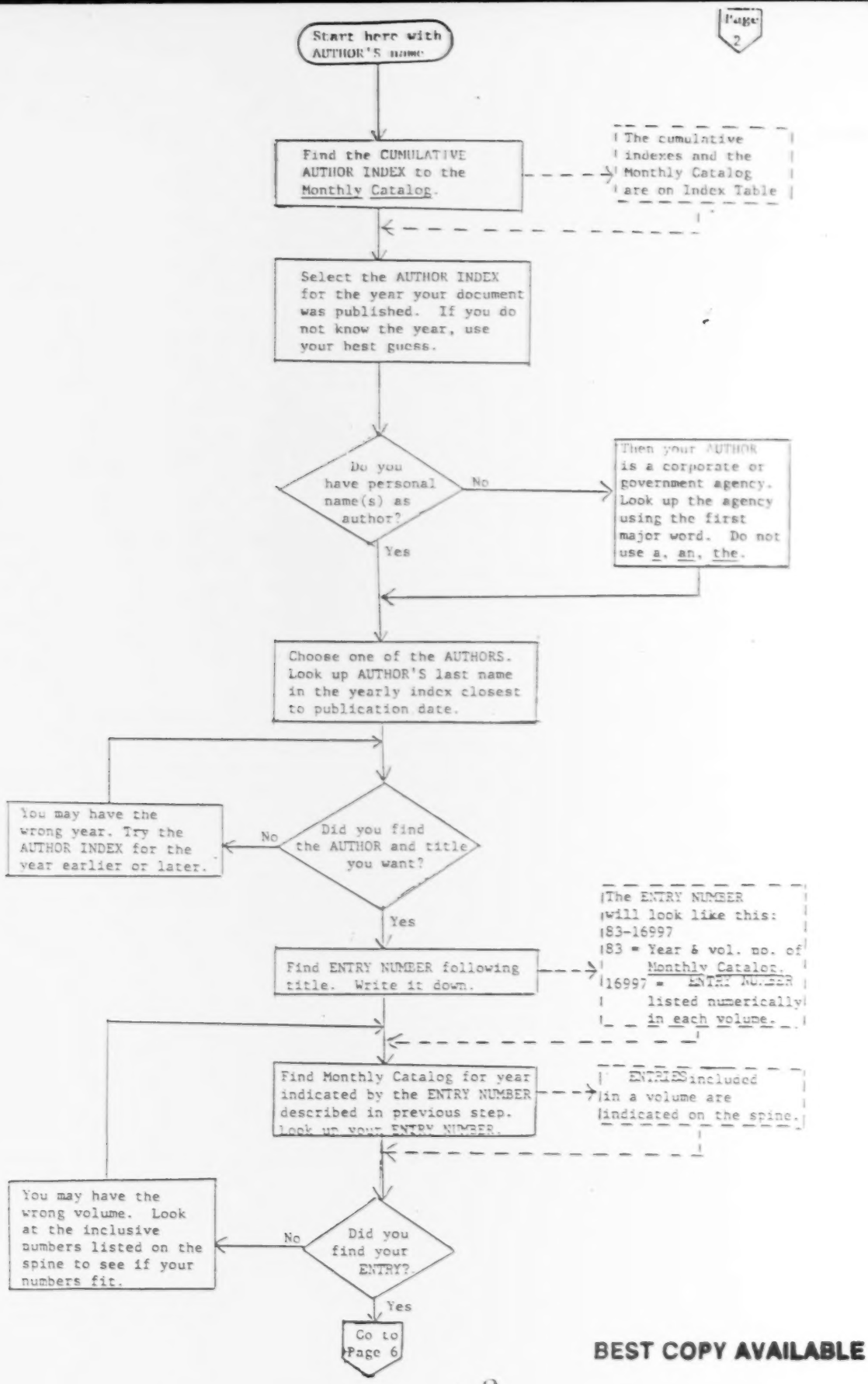
Page 2
Start here with AUTHOR'S name
Find the CUMULATIVE AUTHOR INDEX to the Monthly Catalog.
The cumulative indexes and the Monthly Catalog are on Index Table
Select the AUTHOR INDEX for the year your document was published. If you do not know the year, use your best guess.
Do you have personal name(s) as author?
No
Then your AUTHOR is a corporate or government agency. Look up the agency using the first major word. Do not use a, an, the.
Yes
Choose one of the AUTHORS. Look up AUTHOR'S last name in the yearly index closest to publication date.
Did you find the AUTHOR and title you want?
No
You may have the wrong year. Try the AUTHOR INDEX for the year earlier or later.
Yes
Find ENTRY NUMBER following title. Write it down.
The ENTRY NUMBER will look like this:
83-16997
83 = Year & vol. no. of Monthly Catalog.
16997 = ENTRY NUMBER listed numerically in each volume.
Find Monthly Catalog for year indicated by the ENTRY NUMBER described in previous step. Look up your ENTRY NUMBER.
ENTRIES included in a volume are indicated on the spine.
Did you find your ENTRY?
No
You may have the wrong volume. Look at the inclusive numbers listed on the spine to see if your numbers fit.
Yes
Go to Page 6

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Figure 2

Flow Chart Representation of Algorithm